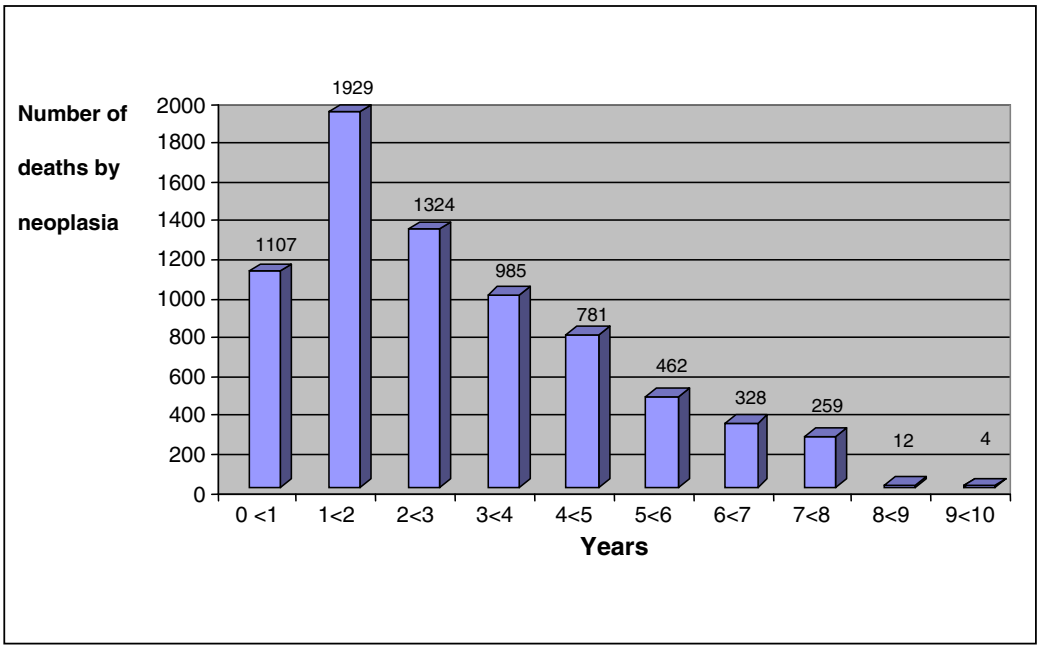
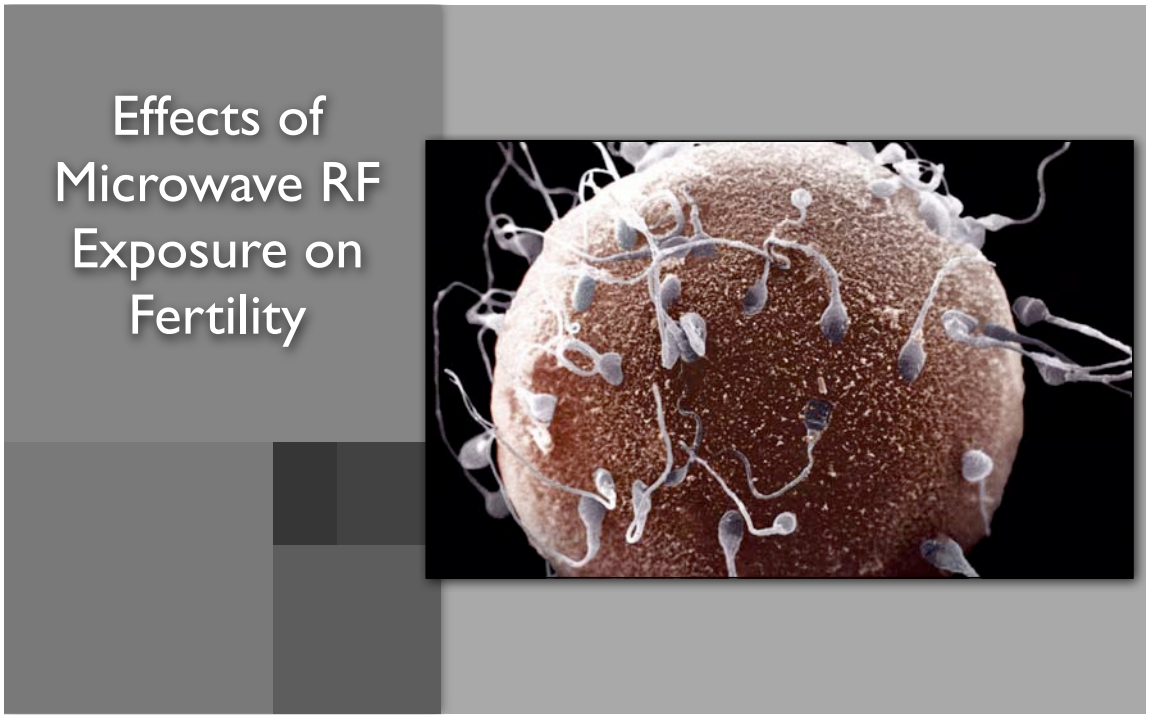
Belo Horizonte, Brazil (2011)



Death rates peaked during the second year of exposure.

Fig. 16. Distribution of the number of deaths by neoplasia versus duration of exposure since the date that the first antenna in each analyzed CT came into operation.

Dode AC, Leao MM, Tejo Fde A et al. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. *Sci Total Environ* (2011); 409(19):3649-3665.



Impaired Fertility in Fruit Flies

Insects are remarkably resistant to ionizing radiation and radioactivity.
They appear to be much more sensitive to the effects of microwave radio frequency exposures.

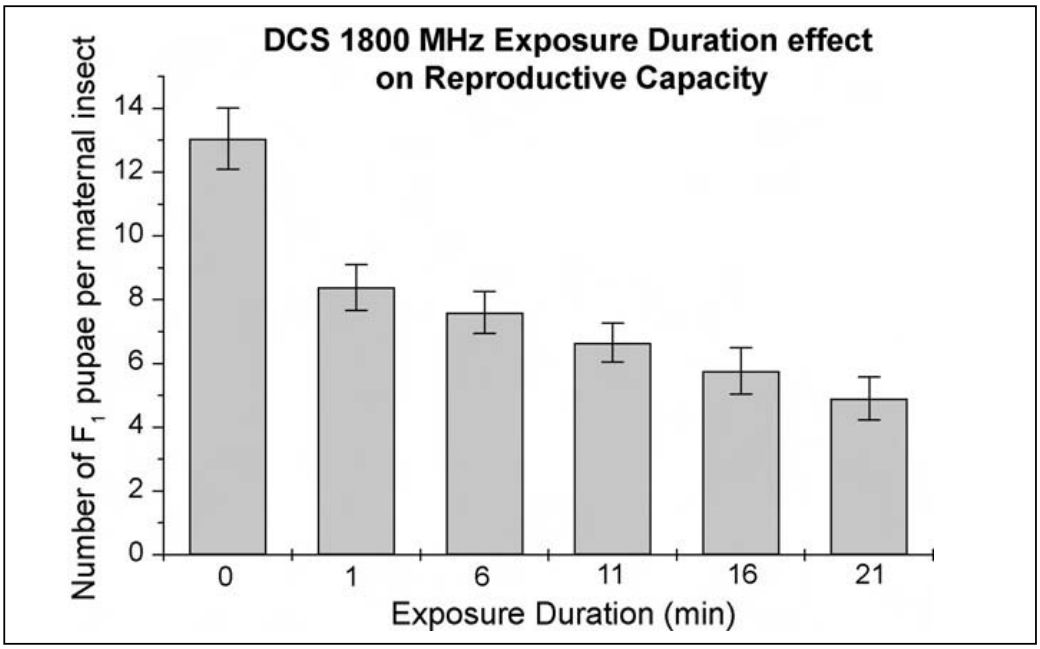
In a recent study, **fruit flies were exposed to 10 µW/cm²** of GSM 900 MHz or 1800 MHz digital RF.

This exposure level is <u>100 times lower</u> than the FCC Guidelines of 1000 µW/cm²

Exposures were for one single exposure intervals per day for five days, ranging from 1 to 21 minutes per day.

Panagopoulos DJ, Margaritis LH. The effect of exposure duration on the biological activity of mobile telephony radiation. *Mutat Res* (2010); 699(1-2):17-22.

Impaired Fertility in Fruit Flies



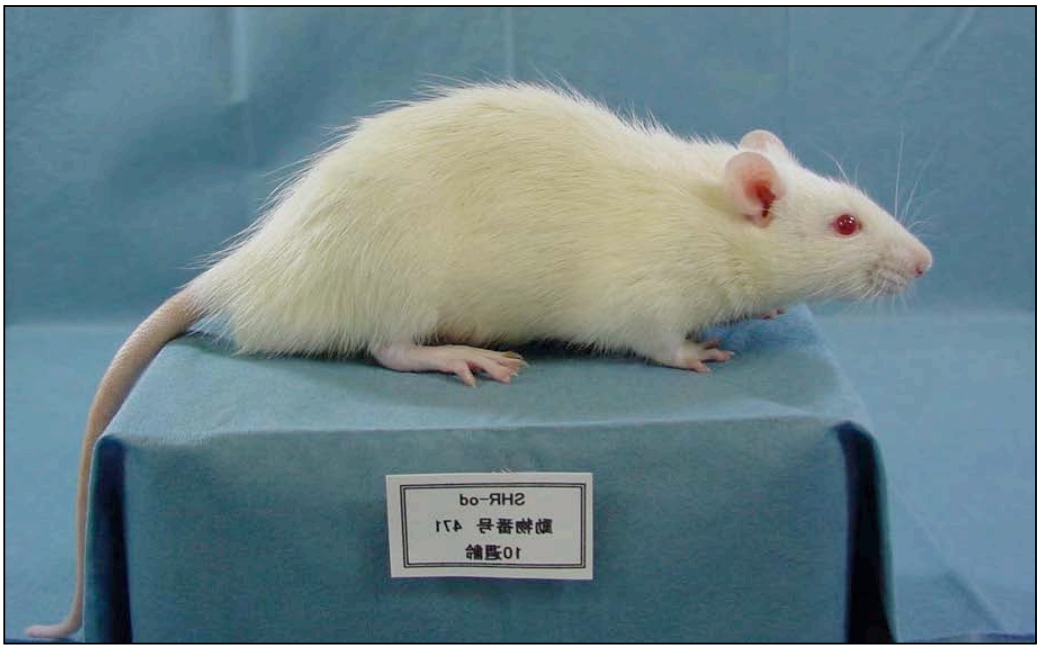
0 = control group, with no exposure.

Even at one minute of exposure per day, a significant decrease in fertility is seen.

Fig. 2. Reproductive capacity (mean number of F1 pupae per maternal fly) of groups exposed to DCS 1800MHz radiation for different daily exposure durations (1, 6, 11, 16, and 21min) for five consecutive days, and of sham-exposed groups (no exposure).

Panagopoulos DJ, Margaritis LH. The effect of exposure duration on the biological activity of mobile telephony radiation. *Mutat Res* (2010); 699(1-2):17-22.

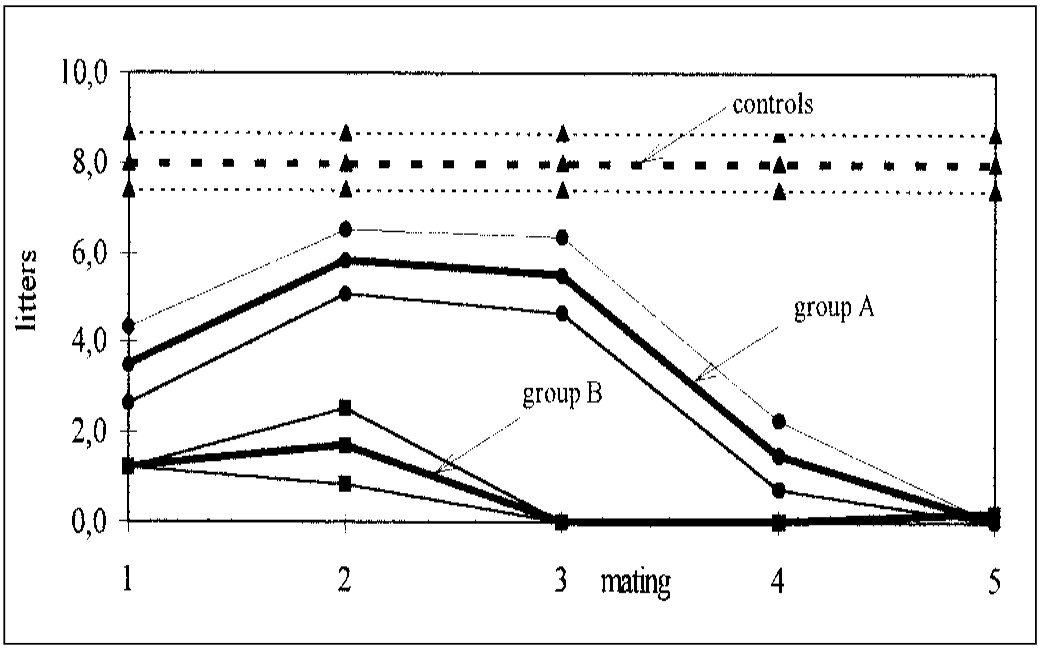
Impaired Fertility in Mammals



This is a Wistar rat.

A great deal of research has been done on the effects of microwave RF on laboratory animals.

Impaired Fertility in Female Mice



In one study, mice were kept in cages in a VHF/UHF antenna park in Thessaloniki, Greece.
Power densities ranged between **0.168 to 1.053 µW/cm²** [reported as 168 - 1053 nanowatts/cm²]

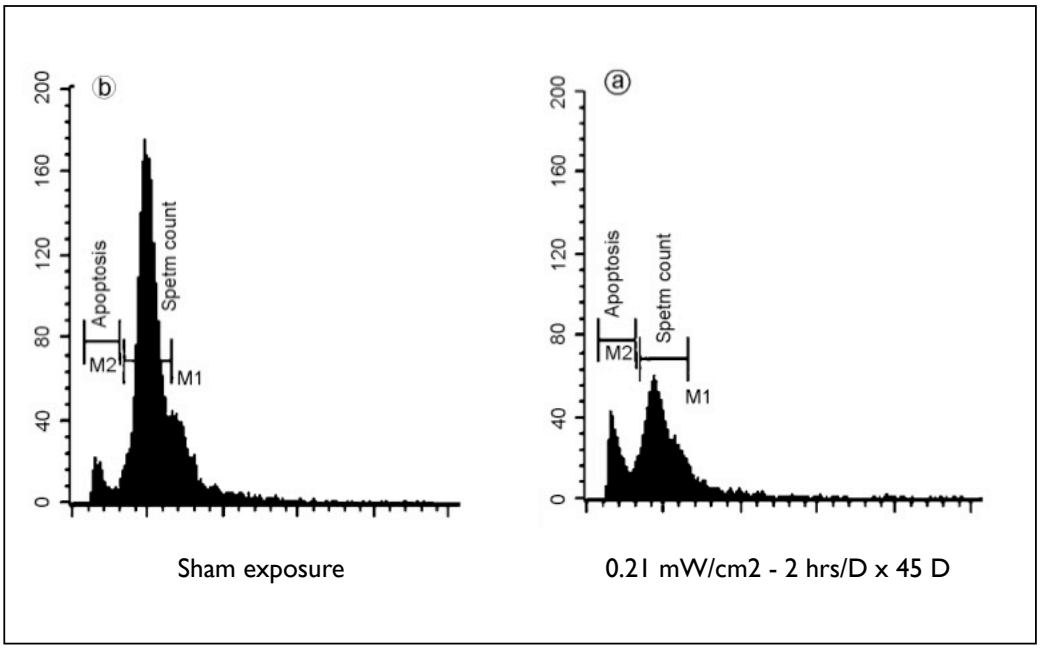
This is about 1000 times lower than the FCC Guidelines of 600-1000 µW/cm²

With repeated matings, litter size decreased, until by the 5th mating, all the dams were infertile.

This infertility was irreversible.

Magras IN, Xenos TD. RF radiation-induced changes in the prenatal development of mice. *Bioelectromagnetics* (1997); 18(6):455-461.

Impaired Fertility in Male Rats



Reduced sperm production in male Wistar rats exposed to 10 GHz microwave RF.

0.21 mW/cm^2 = **<u>one fifth</u> of the FCC Guidelines of 1 mW/cm^2**

OTHER EFFECTS: Increases in reactive oxygen species, increased free radical formation, decreased activity of glutathione peroxidase and superoxide dismutase, DNA strand breakage, increased apoptosis (cell death) in sperm cells, distortion of sperm structure, reduced testosterone levels, shrinkage of seminiferous tubules and testicular size, decreased number and weight of progeny.

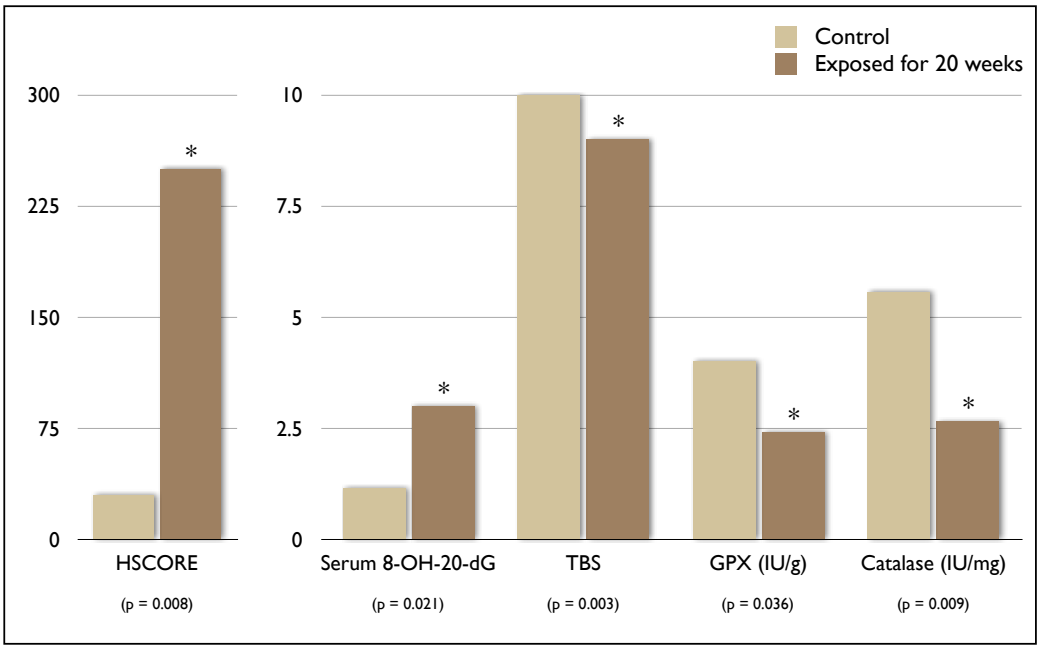
Kesari KK, Kumar S, Behari J. Effects of radiofrequency electromagnetic wave exposure from cellular phones on the reproductive pattern in male Wistar rats. *Appl Biochem Biotechnol* (2011); 164(4):546-559.

Kesari KK, Kumar S, Behari J. Pathophysiology of microwave radiation: effect on rat brain. *Appl Biochem Biotechnol* (2012); 166(2):379-388.

Kumar S, Kesari KK, Behari J. Influence of microwave exposure on fertility of male rats. *Fertil Steril* (2011); 95(4):1500-1502.

Kumar S, Behari J, Sisodia R. Influence of electromagnetic fields on reproductive system of male rats. *Int J Radiat Biol* (2012); epub Nov 13:1-8

WiFi Exposure Damages Sperm With Oxidant Stress.



The rats were exposed to a Standard WiFi gateway, 24 hours a day for 20 days.

HSCORE = histological staining in testes for 8-OH-20-dG
[8-hydroxy-20-deoxyguanosine, **byproduct of DNA damage**]

Serum 8-OH-20-dG (ng/ml) [byproduct of DNA damage]

TBS = testicular biopsy score
9 = Much spermatogenesis, but germinal epithelium disorganized with marked sloughing or obliteration of lumen

GPX = glutathione peroxidase, an antioxidant (consumed by oxidative stress in exposed rats).

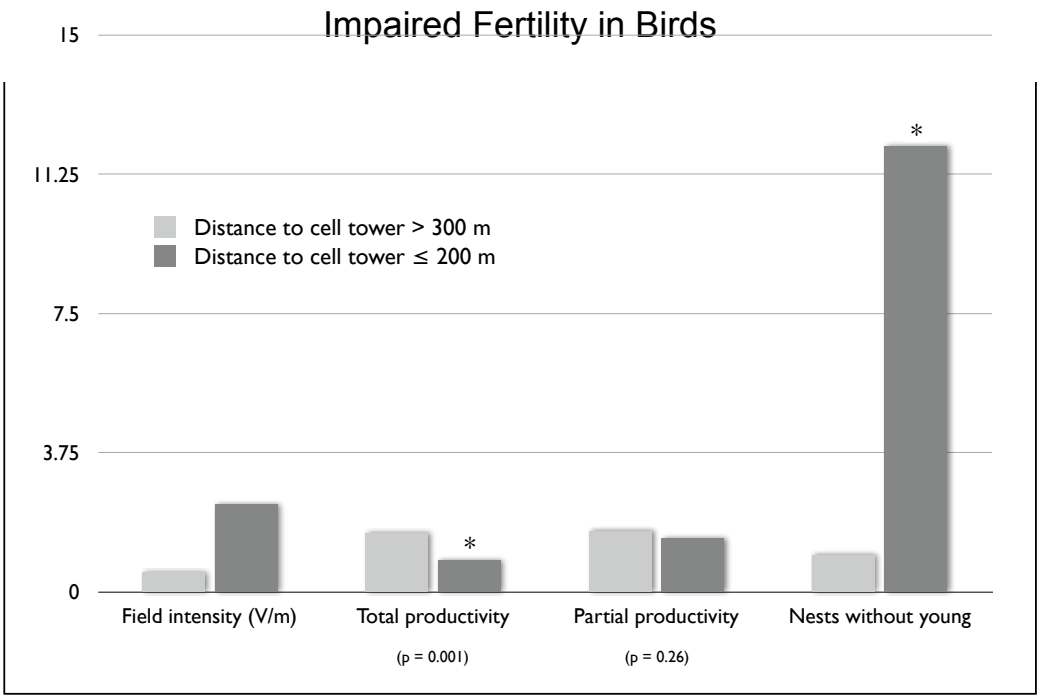
Atasoy HI, Gunal MY, Atasoy P, Elgun S, Bugdayci G. Immunohistopathologic demonstration of deleterious effects on growing rat testes of radiofrequency waves emitted from conventional Wi-Fi devices. *J Pediatr Urol* (2012); March 30.

Impaired Fertility in Birds

In Valladido, Spain, a study compared the productivity of storks nesting closer and farther from a cell phone tower site.

30 nests within 200 meters of the antennae, were compared with 30 nests greater than 300 meters from the antennae

Balmori A. Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork. *Electromagn Biol Med* (2005); 24(2):109-119.



Productivity was significantly reduced in birds in the high exposure group.

Average electric field intensity on nests within 200m = 2.36±0.82V/m **(~ 1.48 µW/cm2**)

This is more than <u>400 times less</u> than the FCC Guidelines of 600-1000 µW/cm^2

Average electric field intensity on nests further than 300m = 0.53 ± 0.82 V/m (~ 0.07 µW/cm2).

Balmori A. Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork. *Electromagn Biol Med* (2005); 24(2):109-119.

Impaired Fertility in Amphibians

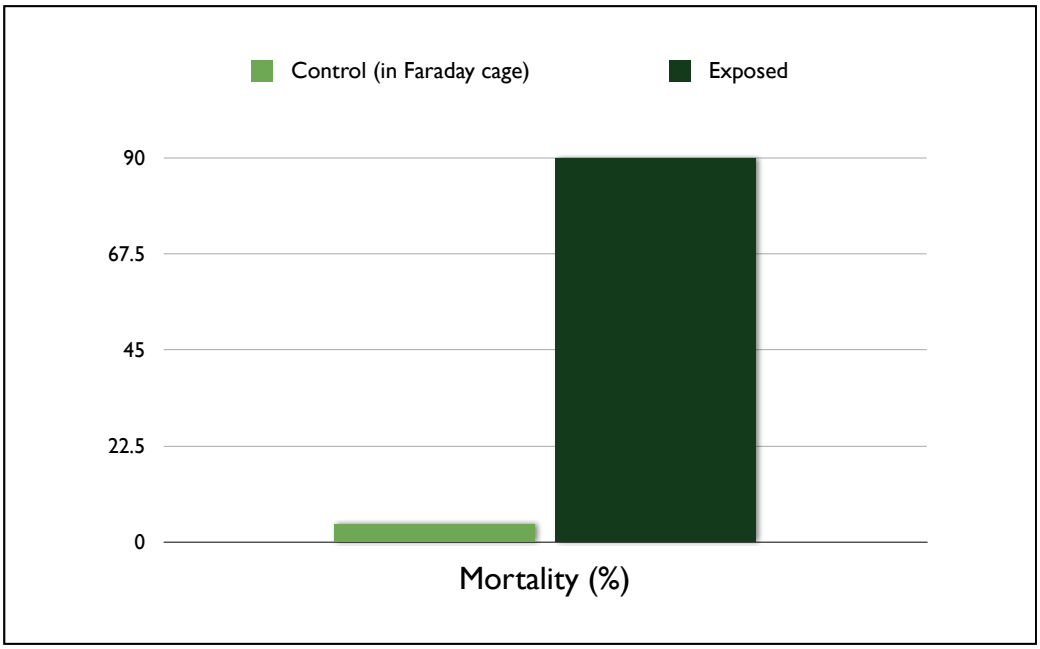
Eggs and tadpoles of the European common frog (Rana temporaria) were exposed to RF/EFM from several cell towers located at a distance of 140 meters.

Duration of exposure was 2 months (from egg phase to advanced tadpole stage).

Control groups were placed in same conditions, but contained in a faraday cage that shielded the eggs from RF exposure.

Balmori A. Mobile phone mast effects on common frog (Rana temporaria) tadpoles: the city turned into a laboratory. *Electromagn Biol Med* (2010a); 29(1-2):31-35.

Impaired Fertility in Amphibians



Exposure intensity 1.8 to 3.5 V/m (~ 0.8–3.2 μW/cm2).

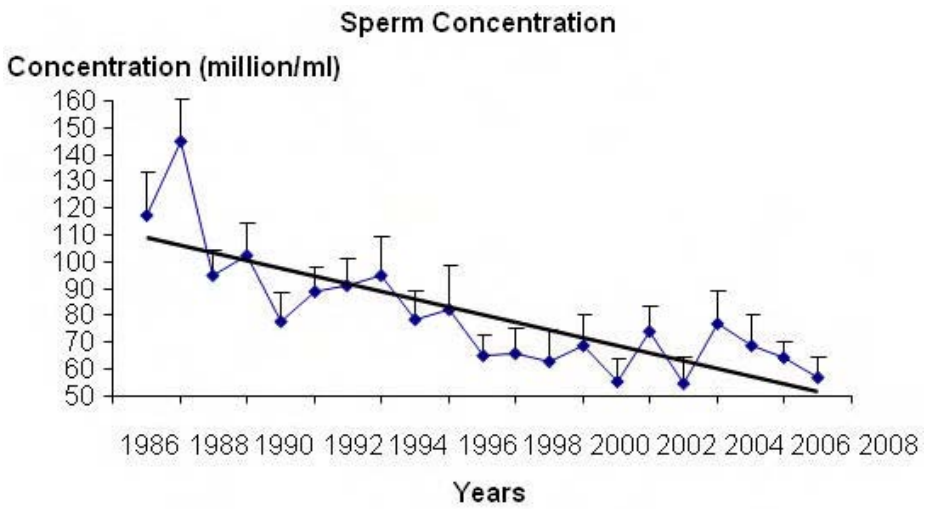
This is <u>200 times less</u> than the FCC Guidelines of 600–1000 μW/cm²

[In the exposed group (n = 70), low coordination of movements and asynchronous growth was observed in living specimens, resulting in both big and small tadpoles. In the control group (n = 70), growth was normal.]

Balmori A. Mobile phone mast effects on common frog (Rana temporaria) tadpoles: the city turned into a laboratory. *Electromagn Biol Med* (2010a); 29(1-2):31-35.

Impaired Fertility in Humans

Figure 2. Sperm concentration in 975 sperm donors recruited over 20 years



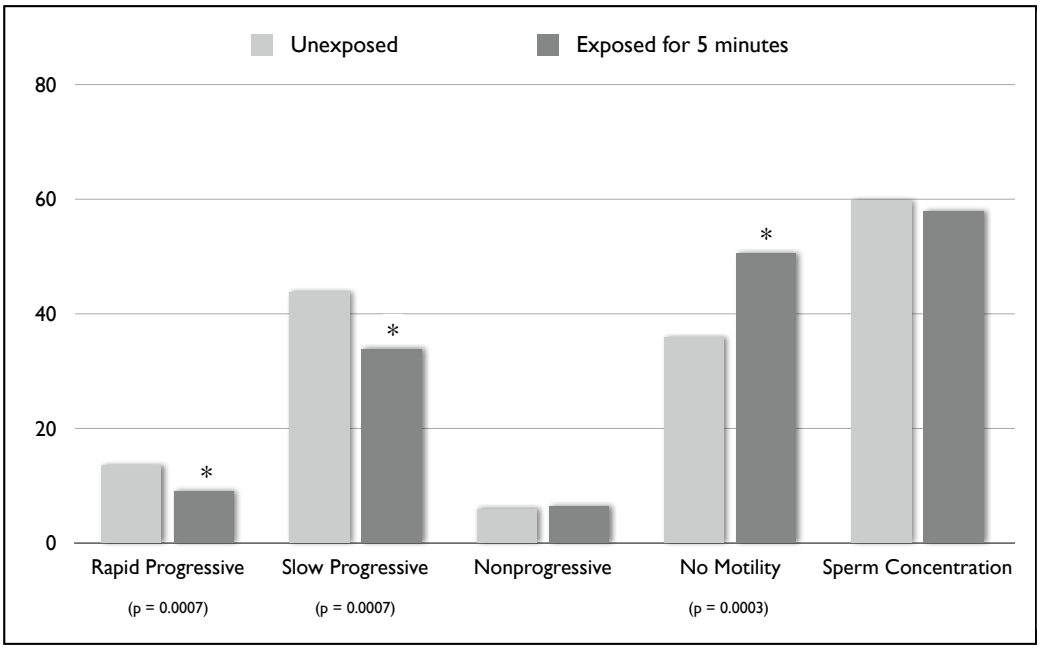
Sperm counts have been dropping worldwide for the last several decades.
(e.g. In New Zealand, 2.5% per year for the last 20 years).

Pesticides have been implicated.

Some evidence suggests that microwave RF exposure may also play a role.

Shine R, Peek J, Birdsall M. Declining sperm quality in New Zealand over 20 years. *N Z Med J* (2008); 121(1287):50-56.

Cell Phone Transmissions Decrease Sperm Motility in Vitro



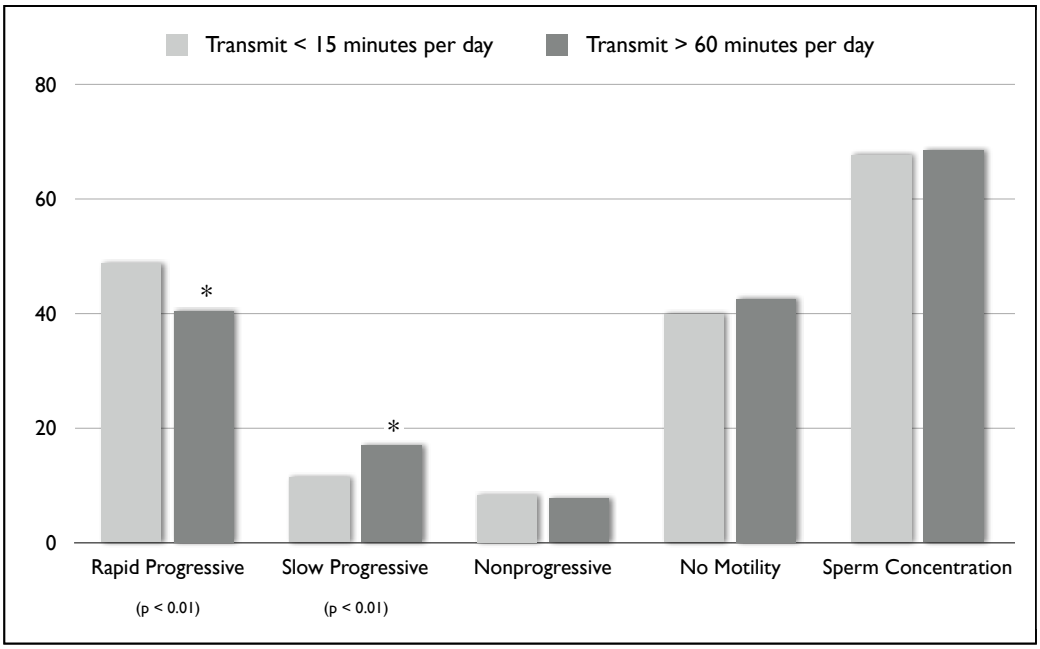
Samples of human sperm received 5 minutes exposure, 10 cm from a transmitting GSM 900 MHz cell phone.
Average power density of exposure: 20 μW/cm^2

This is <u>30 times less</u> than the FCC Exposure Guideline of 600 μW/cm^2

(Y axis = values in %)

Erogul O, Oztas E, Yildirim I et al. Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study. *Arch Med Res* (2006); 37(7):840-843.

Cell Phone Use Decreases Sperm Motility in Vivo



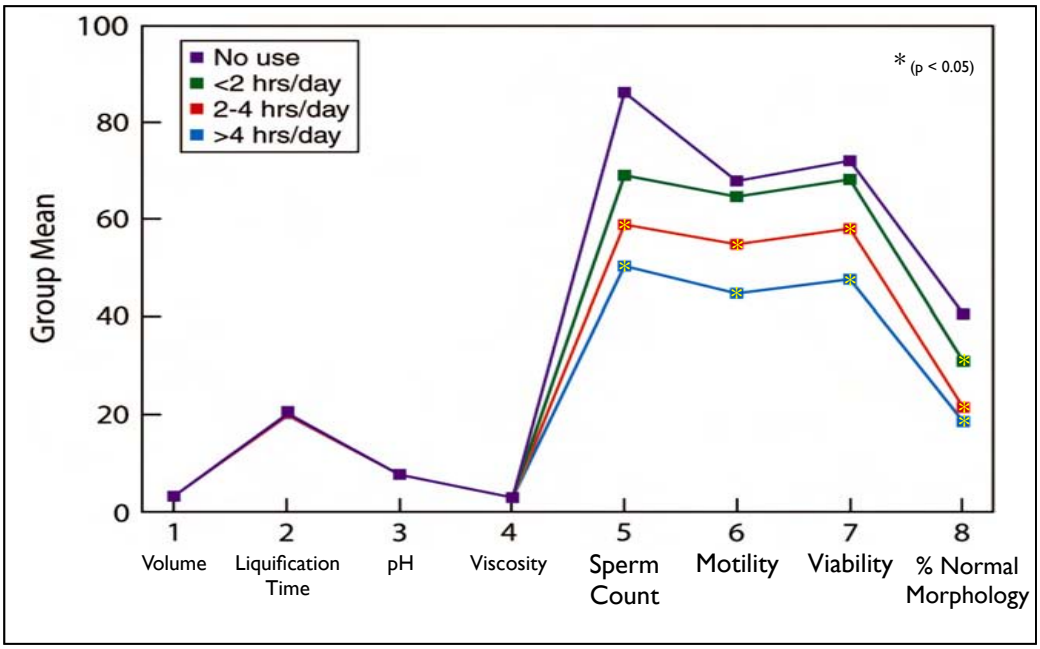
Semen analysis performed on 371 men at a university clinic.

Health questionnaire included query of cell phone use habits.

(Y axis = values in %)

Fejes I, Zavaczki Z, Szollosi J et al. Is there a relationship between cell phone use and semen quality? *Arch Androl* (2005); 51(5):385-393.

Cell Phone Use Degrades Sperm Quality in Vivo



Three hundred sixty-one men undergoing infertility evaluation were divided into four groups according to their active cell phone use:

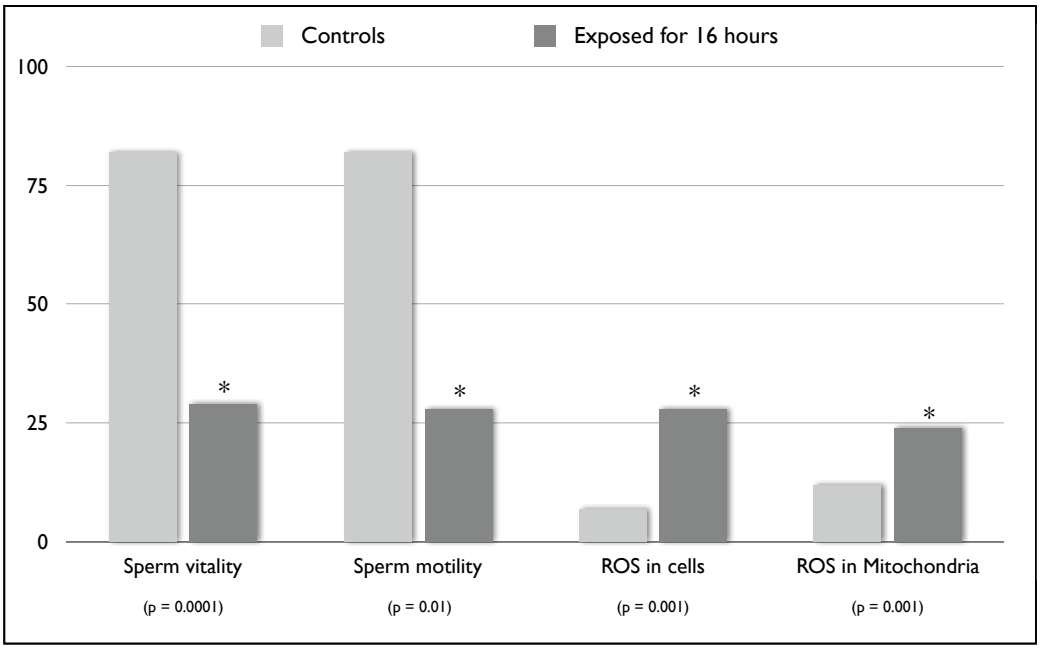
group A: no use; group B: <2 h/day; group C: 2–4 h/day; and group D: >4 h/day.

With greater than two hours a day of reported talk time, significant reduction in **sperm count, motility, viability, and % normal morphology** were observed.

[One can assume that with texting rather than talking, the data might be even worse . . . as the phone antenna will be closer to the testes.]

Agarwal A, Deepinder F, Sharma RK, Ranga G, Li J. Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. *Fertil Steril* (2008); 89(1):124-128.

Isothermal Exposure to 1.8 GHz RF Damages Sperm



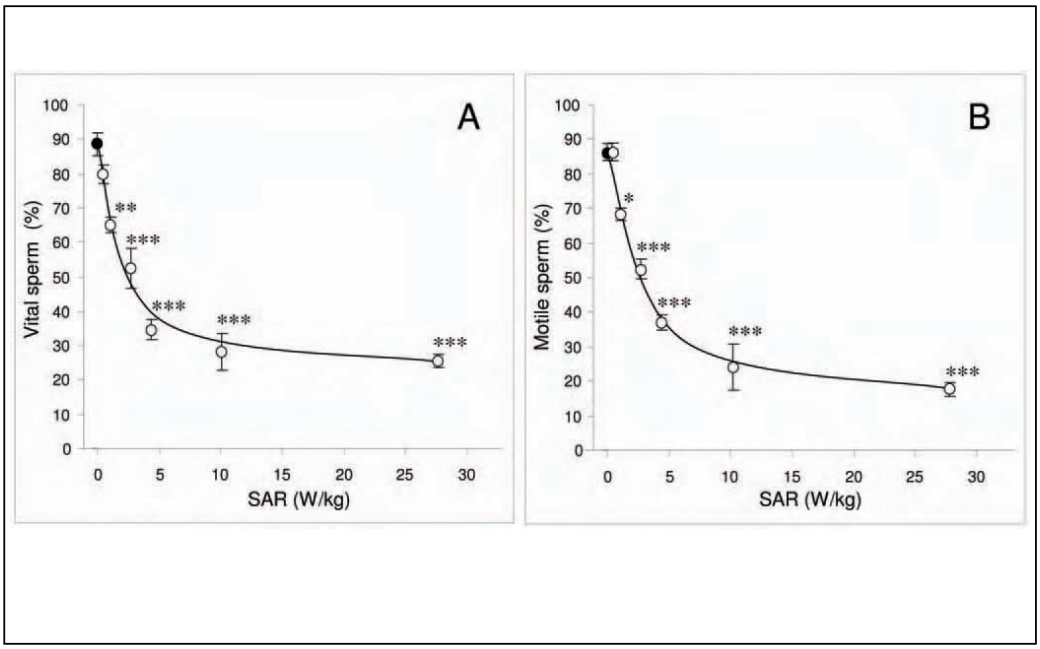
Sperm exposed for 16 hours in vitro to 1.8 GHz (SAR = 27.5 W/kg) @ 21ºC (**isothermal conditions**).

Sperm damage correlates with increased free radical (ROS) production.

Values in %.

De Iuliis GN, Newey RJ, King BV, Aitken RJ. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* (2009); 4(7):e6446 (1-9).

1.8 GHz RF Degrades Sperm Quality In Vitro



1.8 GHz RF at various intensities for 16 hours @ 21ºC

This is an isothermal exposure

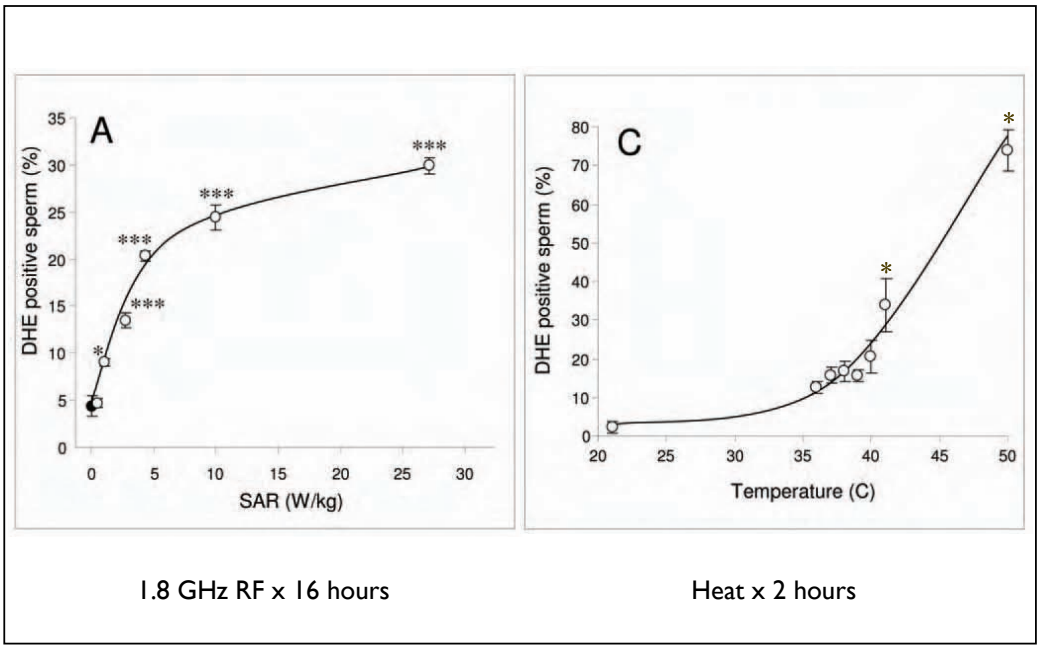
Sperm vitality and motility are significantly detraded at SAR = 1 W/kg and above

Figure 2. RF-EMR exposure reduces motility and vitality of human spermatozoa, in an SAR dependent manner. Percoll-purified spermatozoa (5 x 10^6 cells) were suspended in 1 ml BWW in a 35 mm Petri dish and placed within the waveguide while control cells (closed circles) were placed outside the waveguide. Cells in the waveguide were exposed to 1.8 GHz RF-EMR at SAR levels of 0.4, 1.0 2.8 4.3 10.1 and 27.5 W/kg (open circles) for 16 h at 21uC. Both vitality and motility were reduced in a dose dependent manner.

A, Vitality was significantly reduced at a SAR of 1.0 W/kg from 89% ±3% to 65% ±1% (**p,0.01).

B, Motility was also significantly reduced at a SAR of 1.0 W/kg from 86% ±2% to 68% ±2% (*p,0.05). All results are based on 4 independent samples.

ROS Production – RF versus Thermal



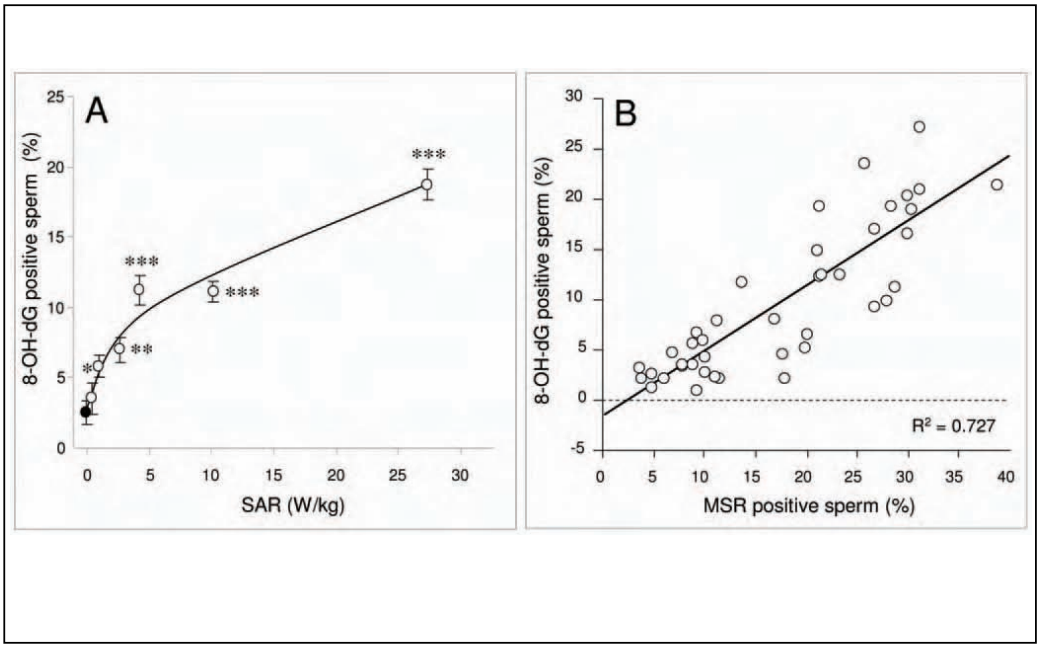
A. ROS generation (DHE response) was significantly increased from control levels after exposure to 1.0 W/kg (*p, 0.05) and above (***p,0.001).

C. In order to control for thermal effects, the impact of temperature of cellular ROS generation was monitored; a significant increase in ROS generation was observed as temperatures rose above 40°C (p,0.001).

Figure 3. RF-EMR induces ROS generation in human spermatozoa, in an SAR-dependent manner unrelated to thermal effects.

De Iuliis GN, Newey RJ, King BV, Aitken RJ. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* (2009); 4(7):e6446 (1-9).

Oxidative Damage To Sperm DNA From 1.8 GHz RF Exposure



1.8 GHz RF x 16 hours @ 21°C isothermal.

A) As the power levels were increased, the amount of oxidative DNA damage expressed also increased.

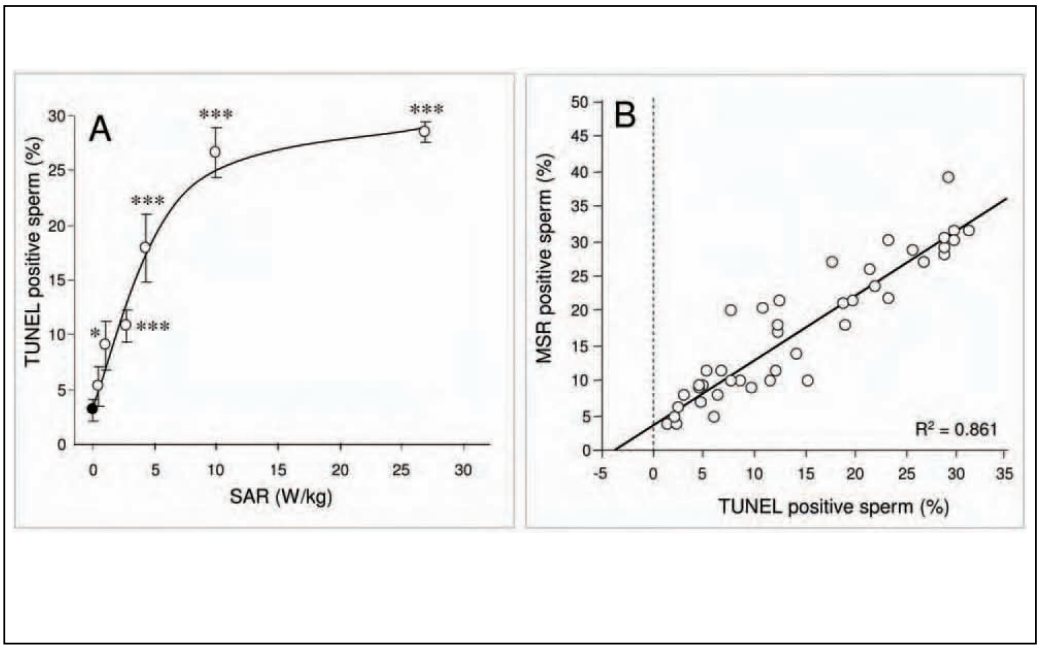
A significant amount of oxidative DNA damage was observed in cells exposed to 2.8 W/kg (*p,0.05) RF-EMR and above (**p,0.01; ***p,0.001).

B) The levels of 8-OH-dG expression were positively correlated with the levels of ROS generation by the mitochondria (R2 = 0.727).

Figure 4. RF-EMR induces oxidative DNA damage in human spermatozoa.

De Iuliis GN, Newey RJ, King BV, Aitken RJ. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* (2009); 4(7):e6446 (1-9).

RF Damages Sperm by Increasing Oxidative Stress



A) Significant levels of DNA fragmentation was observed in exposed spermatozoa at 2.8 W/kg (*p,0.05) and above (***p,0.001).

B) DNA fragmentation was positively correlated with ROS production by the mitochondria as monitored by MSR. (R2 = 0.861).

Figure 5. RF-EMR induces DNA fragmentation in human spermatozoa.

De Iuliis GN, Newey RJ, King BV, Aitken RJ. Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* (2009); 4(7):e6446 (1-9).

Sperm Damage From Laptop WiFi

Motile spermatozoa in semen were incubated at room temperature,

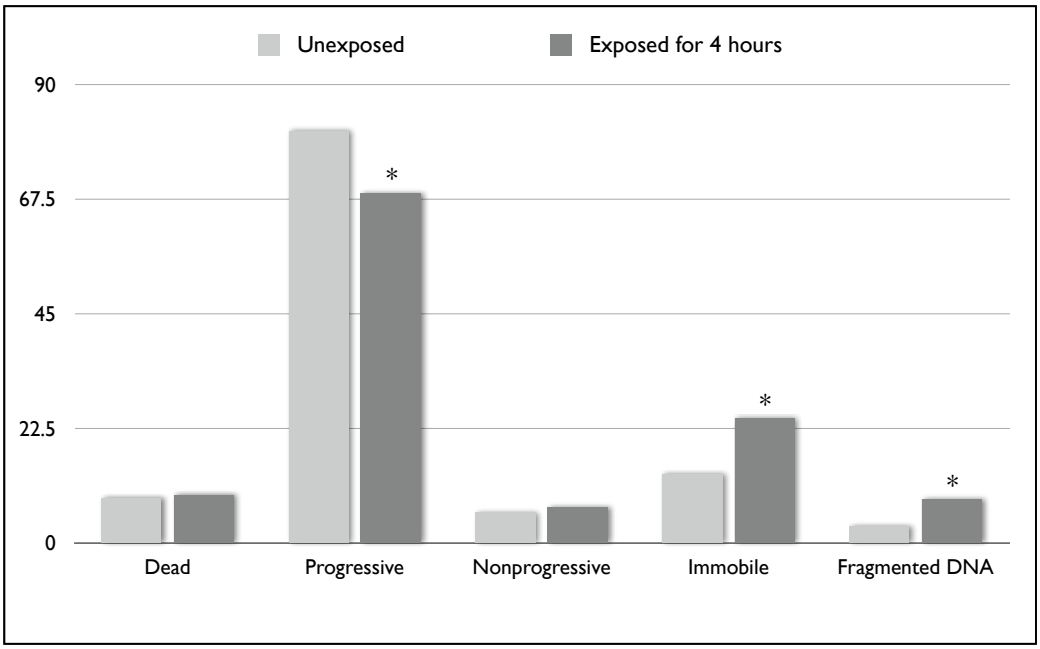
3 cm below laptop computer (e.g. lap distance)

4 hours of exposure.

Control incubated in similar conditions, without presence of the computer.

Avendano C, Mata A, Sanchez Sarmiento CA, Doncel GF. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation. *Fertil Steril* (2012); 97(1):39-45.

Sperm Damage From Laptop WiFi



Power density ranged 0.45 to 1.05 μW/cm^2

[This is roughly **1000 times less than the FCC exposure limit** of 1000 μW/cm^2]

Avendano C, Mata A, Sanchez Sarmiento CA, Doncel GF. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation. *Fertil Steril* (2012); 97(1):39-45.